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Glenohumeral arthrodesis for late reconstruction of flail shoulder in patients with traumatic supraclavicular brachial plexus palsy

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Abstract

Background: Flail shoulder can occur following a brachial plexus injury and is characterized by painful subluxation of the glenohumeral joint and the inability to independently position the hand in space. The present study aimed to report the clinical outcomes following glenohumeral arthrodesis for late reconstruction of flail shoulder in patients with traumatic supraclavicular brachial plexus palsy.

Methods: Seven patients were included in the present study and were followed-up for a mean of 98 months (range 27 months to 197 months). The mean age at the time of surgery was 48 years (range 28 years to 80 years) and the mean time to surgery from injury was 5 years (range 2.5 years to 8 years).

Results: Six patients achieved bony union with a mean time to fusion of 4.7 months (range 2 months to 8 months). Non-union occurred in one case. The mean Oxford Shoulder Score improved from 11 pre-operatively (range 4 to 16) to 27 postoperatively (range 16 to 40) ($p = 0.016$), and the mean Subjective Shoulder Value improved from 7 (range 0 to 15) pre-operatively to 45 (range 15 to 100) postoperatively ($p = 0.029$).

Conclusions: In our series, glenohumeral arthrodesis was associated with few complications, and effectively reduced pain and improved functional outcome in this selected patient population.

Keywords

arthrodesis, brachial plexus, flail shoulder, fusion, shoulder, supraclavicular

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Introduction

Traumatic injuries of the brachial plexus can cause devastating loss of upper limb function and can pose a significant challenge to conventional management strategies. Primary surgical reconstruction is most effective when undertaken soon after the injury and comprises direct nerve repair, neurolysis for scar compression, nerve grafting and nerve transfers.[1] After 6 months to 9 months, these procedures are less reliable because time-dependent changes occur in the motor endplate that limit reinnervation potential.[1–3] Patients that present outside this optimal time frame and those who fail to recover function following initial surgery may be left with a flail shoulder.[4]

Flail shoulder is characterized by painful subluxation of the glenohumeral joint and the inability to independently position the hand in space.[4] This causes significant disability that interferes with normal activities of daily living and limits employment opportunities. Patients are often young and so there is great emphasis on functional restoration of the upper limb.[4] Several surgical options have been proposed, including direct nerve repair and muscle/tendon transfers, although the results of these are less predictable than those for the elbow or hand.[5–7]

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Glenohumeral arthrodesis reduces pain, restores stability, and achieves movement through the scapulothoracic joint.[4,8] In doing so, it places the arm and hand in a functional position and may therefore be used to improve upper limb function in patients who are not candidates for prosthetic replacement. However, there are few reports examining this treatment strategy in cases of brachial plexus palsy with those that do reporting high complication rates: non-union and prominent hardware.[4,9]

The aim of this retrospective cohort study was to report the results of glenohumeral arthrodesis for late reconstruction of flail shoulder in patients with traumatic supraclavicular brachial plexus palsy.

Materials and methods

Between May 2000 and July 2014, glenohumeral arthrodesis was carried out on 21 consecutive patients in our study institution who were identified using a computerized database. Of these, seven cases were a result of flail shoulder that occurred following a high-energy road traffic accident. Upon hospital presentation, all patients were found to have traumatic supraclavicular (combined upper and middle trunk) brachial plexus palsy characterized by absent rotator cuff, deltoid and biceps function. All cases were performed by the senior author (SML).

Prior to arthrodesis, three patients had procedures to improve elbow function (numbers 1, 4 and 7): ulnar nerve to biceps transfer, latissimus dorsi to biceps transfer and pectoralis minor to biceps transfer. All patients recovered active elbow flexion against resistance after surgery. To improve shoulder function, accessory to suprascapular nerve transfer was undertaken on two cases (numbers 4 and 7). This was unsuccessful and all patients were considered for glenohumeral arthrodesis.

All clinic notes and operative reports were reviewed. The mean age at the time of surgery was 48 years (range 28 years to 80 years). The cohort consisted of six males and one female. The dominant arm was affected in three cases. The mean time to surgery from the date of injury was 5 years (range 2.5 years to 8 years). The indications for arthrodesis included persistent discomfort in the dependent extremity that was improved by the use of a humeroscapular dynamic support, the inability to abduct the extremity to permit a thoracobrachial 'grasp' to be achieved, and absent rotational control in the glenohumeral joint in the presence of a useful elbow, forearm and hand. Detailed patient data are presented in Table 1.

Surgical technique

Surgery was performed according to a previously published protocol.[8] A posterosuperior–anterolateral approach was used in all cases. To determine the position of arthrodesis, the arm was placed in the position favoured by the patient after discussion with occupational and physical therapists. This was usually with the ipsilateral hand placed over the mouth and the elbow raised away from the side of the body so that ipsilateral axillary hygiene was possible (the surgeon's hand could be comfortably placed in the axilla). Temporary pinning of this position allowed further adjustments to be made. It was considered important to avoid a position of excessive internal rotation: if anti-gravity elbow flexion power was available, then a markedly internally rotated shoulder would bring the hand into the abdomen rather than into a functional range anterior to the midline of the trunk. It is recognized that the optimum position of arthrodesis is controversial and we recommend that it should be adjusted to each patient's requirements.

The humeral head and glenoid were prepared by removing their articular cartilage and making the two surfaces spherically congruent using reamers from a humeral resurfacing set and equivalent glenoid preparation instruments (Epoca; DePuy Synthes, Leeds, UK). A 4.5-mm 10- or 12-hole narrow tibial dynamic compression or locked compression plate (DePuy Synthes) was contoured to match the spine of the scapula, the acromion and the anterolateral surface of the humerus (Fig. 1). Morcellized bone from the humerus and scapula was used to pack the fusion site. This technique was used in all but two cases. In these patients (numbers 3 and 7), arthrodesis was achieved using two transhumeral lag screws (Fig. 2).

Postoperatively, a thoracobrachial spica was used for 3 months to protect the fusion during the time that union occurred: isometric scapular suspension muscle exercises were advocated when in the spica. A sling was subsequently used to permit transition to the scapular mobilization programme.

Assessment of functional outcome

Pre-operative and postoperative clinical and radiographic data were collected on all patients. All patients were evaluated using the Oxford Shoulder Score (OSS) and Subjective Shoulder Value (SSV).[10,11]

Statistical analysis

A paired *t*-test was used to compare OSS and SSV before and after surgery. $p < 0.05$ was considered statistically significant. SPSS, version 23 (SPSS Inc., IBM Corp., Armonk, NY, USA) was used to analyze data.

Results

All patients were follow-up for a minimum of 24 months, except one (number 5) who was lost

Table 1. Patient details.

Patient	Sex	Age (years)	Previous brachial plexus surgery	Duration of follow-up (months)	Outcome at latest follow-up	Oxford Shoulder Score (pre-operative/ postoperative)	Subjective Shoulder Value (pre-operative/ postoperative)	Additional procedures
1	Male	80	Latissimus dorsi to biceps tendon transfer	27	Union	9/40	10/100	–
2	Male	56	Supraclavicular neurolysis	56	Union	4/29	0/45	–
3	Female	31	–	69	Union	9/28	5/30	–
4	Male	62	Accessory to suprascapular nerve transfer Ulnar nerve to biceps transfer Pectoralis minor to biceps tendon transfer	114	Union	11/22	10/30	–
5	Male	39	–	–	Union	–	–	–
6	Male	28	–	123	Union	16/16	15/15	–
7	Male	42	Accessory to suprascapular nerve transfer Ulnar nerve to biceps transfer Pectoralis minor to biceps tendon transfer	197	Union	15/26	0/50	Revision arthrodesis because of non-union

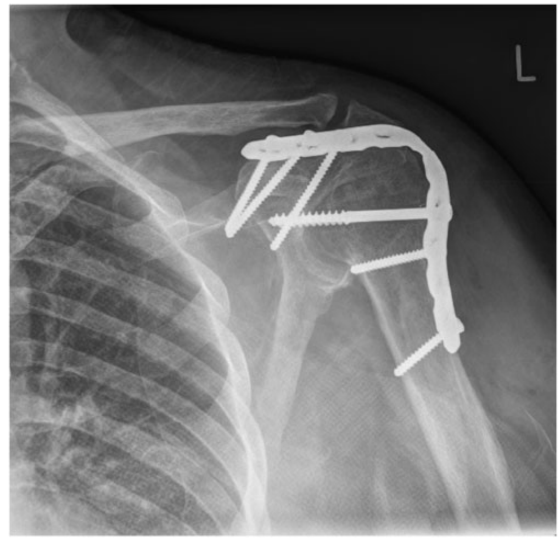

Figure 1. Anteroposterior radiograph of an 80-year-old right, hand-dominant female, 2 months after left glenohumeral arthrodesis using a locked compression plate (DePuy Synthes).

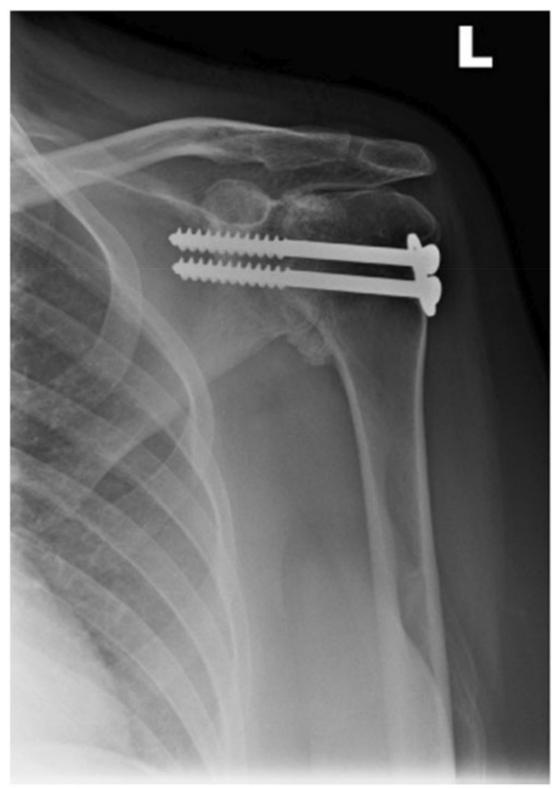

Figure 2. Anteroposterior radiograph of a 31-year-old right hand-dominant female, 7 months after left glenohumeral arthrodesis using two transhumeral lag screws.

to-follow up after radiographic fusion was achieved and thus excluded from functional outcome analysis. In this group, the mean follow-up was 98 months (range 27 months to 197 months). Six patients achieved

Table 2. Change in the Oxford Shoulder Score following glenohumeral arthrodesis.

Item	Number of patients reporting an improvement	Number of patients reporting worsening	Number of patients reporting no change
Worst pain	5		1
Dressing oneself	3		3
Getting in and out of a car or using public transport	3	1	2
Using a knife and fork simultaneously	1		5
Doing household shopping independently	3		3
Carrying a tray containing a plate of food across a room	4		2
Brushing/combing hair with the affected arm	2		4
Usual pain from shoulder	5		1
Hanging clothes up in a wardrobe using affected arm	4		2
Washing and drying under both arms	3		3
Effect of shoulder pain on usual work including housework	4		2
Nocturnal pain	5		1

bony union, with a mean time to fusion of 4.7 months (range 2 months to 8 months). Non-union occurred in one case (number 7) where arthrodesis was initially undertaken using two transhumeral lag screws. No infective cause was identified and the patient underwent revision arthrodesis 3 years later using the technique described above, in conjunction with Osteogenic Protein-1 (Osigraft, OP-1; Stryker Biotech, Newbury, UK) to facilitate fusion. Union was achieved, and the functional outcome was excellent, as indicated by an improvement in the OSS and SSV. No further complications/re-operations were noted and, importantly, no cases of scapulothoracic pain or dyskinesis were reported at the latest review.

In the six cases eligible for functional outcome assessment, the mean OSS significantly improved from 11 pre-operatively (range 4 to 16) to 27 postoperatively (range 16 to 40) ($p = 0.016$). This was accompanied by a significant increase in the mean SSV, which improved from 7 (range 0 to 15) pre-operatively to 45 (range 15 to 100) postoperatively ($p = 0.029$).

There were no cases of residual or perceived instability, and no patient developed painful/non-painful scapular dyskinesis. Of the six patients available for functional outcome analysis, a reduction in pain was noted in five cases and all but one patient (number 6) reported an improvement in upper limb function (characterized by an increase in the OSS). The results from the OSS are summarized in Table 2.

Discussion

Brachial plexus injuries frequently lead to serious physical disability, psychological distress, and socioeconomic difficulty.[12] Management is complex and best provided at specialist centres with expertise in diagnosis, treatment and rehabilitation. Late reconstruction is considered when patients present outside the optimal time frame for reinnervation or have poor function following initial surgery.[12] One of the main priorities of this approach is to restore shoulder girdle function as a platform for the remainder of the upper extremity, particularly if there is a powerful and functionally useful hand and forearm.[1] This can be achieved by providing stability and reducing the pain from recurrent or persistent inferior glenohumeral subluxations. Glenohumeral capsular procedures are only of value if there is strength sufficient for stability and motion control from the rotator cuff. Reverse shoulder arthroplasty is valuable if there is a functioning deltoid in the absence of a powerful rotator cuff; a fixed-fulcrum shoulder arthroplasty can be of benefit in cases in

which the deltoid function is weak, even absent, where retaining some rotational freedom in low level daily activities, as driven through a weak posterior rotator cuff or muscle transfer, is desirable. Arthrodesis remains a useful option in cases where the rotator cuff function is absent and deltoid function is less than MRC Grade 3, particularly if there is instability or articular surface damage at the glenohumeral joint.

Subsequent to the inception of arthroplasty, the indications for glenohumeral arthrodesis have diminished. Functional outcome is varied as a result of the complications associated with the procedure, namely non-union, the need for metalwork removal and an unacceptable arm position.[13] Currently, the main controversies surrounding shoulder fusion are the method of fixation, the use of grafts to augment bony union, the need for immobilization and the position of the arm. These are all crucial to achieving a successful outcome, although the relative scarcity with which the procedure is now undertaken makes it difficult to undertake meaningful analysis of the literature. Nevertheless, glenohumeral arthrodesis in the modern era of reconstructive shoulder surgery is gaining in popularity and is being used to treat an array of complex conditions that are not amenable to prosthetic replacement, such as local tumours of the pectoral girdle and seizure-related instability.[8,14] Supraclavicular brachial plexus palsy however, remains one of its most common indications.[4,15–17] Atlan et al.[17] reported the results of 54 patients who had shoulder arthrodesis, using a non-locking plate, for flail shoulder resulting from traumatic brachial plexus injury. Two types of bone graft were used throughout the cohort: subacromial corticocancellous and cancellous only grafts. Postoperative immobilization was variable with only six patients using an abduction splint. Bony union was achieved in 76% of cases (41 of 54 patients) and the use of the cancellous bone graft was associated with a significantly higher rate of pseudarthrosis. Of the 13 cases of non-union, 11 had no postoperative immobilization. Other complications included four fractures and two surgical site infections of which one required removal of the metalwork and revision arthrodesis.

Chammas et al.[18] compared the functional outcome after shoulder fusion for post-traumatic supraclavicular brachial plexus palsy between two groups of adult patients: upper palsy with a functional hand (group A) and total palsy with a flail hand (group B). Internal fixation with screws followed by immobilization in a cast was performed in six patients, and a Hoffmann external fixator combine with screw fixation was used in 21 patients. Twenty-seven patients were included for study and mean postoperative follow-up was 70 months for group A (11 patients) and 72 months for group B (16 patients). Six complications occurred: three fractures, two non-unions that required revision arthrodesis and bone grafting, and one infection. Following surgery, 26 patients experienced a subjective improvement in their condition suggesting that the presence of a flail hand pre-operatively was not a negative prognostic indicator. Richards et al.[4] reviewed 14 patients in whom shoulder arthrodesis was undertaken for brachial plexus palsy using a dynamic compression plate. All patients were immobilized in a spica cast and followed up for a mean of 32 months. All shoulders fused but three patients complained of persistent pain and seven patients required plate removal.

A number of techniques of arthrodesis have been described in the literature, including isolated trans-articular screw fixation, plate fixation, and external fixation.[4,8,18] Miller et al.[19] undertook a biomechanical analysis of these procedures and found that plate fixation exhibited significantly greater bending and torsional stiffness compared to external fixation and trans-articular screws. This alone though should not be the only consideration when determining the most appropriate method of fusion because trans-articular screws can be inserted using a minimally invasive arthroscopic approach, and external fixation may negate the need for cumbersome cast immobilization.[18,20]

Our series suggests that glenohumeral arthrodesis is a viable salvage procedure that may be used effectively to improve upper limb function following traumatic supraclavicular brachial plexus palsy. By contrast to previous studies, the complication rate was low and there were no cases of hardware-related issues that necessitated plate removal in the medium term. We consider that the surgical protocol of internal fixation followed by postoperative immobilization was essential for achieving a good outcome. In the only case of non-union (number 7), fusion was attempted using two isolated screws. This is a relatively common sequela of fusion surgery in this population because of the presence of disuse osteoporosis, poor muscular control and decreased proprioception resulting from impaired neuronal activity.[4] Postoperatively, an overall improvement was noted in the SSV and OSS with a mean of a 38- and 16-point change, respectively: predominantly as a result of less pain and greater stability. In one case (number 6), there was no change in symptoms. This was the youngest patient in the cohort who found maintenance of the arm in a relatively fixed position to be restrictive to all aspects of his life. Similar findings have been reported in previous studies of glenohumeral arthrodesis in young patients, who as such, should be counselled rigorously before undergoing surgery.[8] In our unit, all patients who are suitable for shoulder fusion are encouraged to contact other patients who

have had the procedure to enhance their understanding of the functional limitations that they may encounter, as well as ways of overcoming them.

The limitations of the present study include its retrospective nature and the use of two operative techniques. A relatively small number of cases was included for analysis, although this is because of the rarity of flail shoulder resulting from traumatic supraclavicular brachial plexus palsy.

In conclusion, flail shoulder in patients with traumatic supraclavicular brachial plexus palsy poses a significant challenge. The main aim of management is to provide a stable shoulder that allows the hand to be positioned in space such that the patient can carry out basic functions of daily living. In our series, glenohumeral arthrodesis was associated with few complications, and effectively reduced pain and improved functional outcome in this selected patient population. With use of the operative technique described, fusion can be reliably obtained and we therefore advocate the procedure as a component of upper limb rehabilitation in patients with no recovery of the shoulder following brachial plexus palsy and neurotization procedures.

Declaration of Conflicting Interests

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